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Old Series Vol. 27 TORONTO, SEPT., 1914 New Series Vol. IX. No. 5

"A DESIGN OF A POWER PLANT"

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(*Concluded from last issue*)

PART II

The design of the actual plant must next be considered and the dam comes first. For power purposes, it is the structure closing the river valley so that the water may be accumulated, the fall concentrated and the flow diverted in the desired direction. It may or may not have water passing over it or through it. Generally it is provided with bays in which are stop logs that may be removed to let the flood water run away without flooding the lands above the dam by raising the water too high.

The general principles of the construction of dams are:—

1. They must have suitable foundations that prevent the passage of water under them, and are able to sustain the pressures on them due to the pressure of the water and weight of the superstructure.
2. They must be stable against sliding.
3. They must be safe against overturning.
4. They must be strong enough to withstand the shock due to ice, floating timber, etc.
5. They must be practically watertight.
6. They must have water tight connections with the river banks.
7. They must be so designed as to prevent scouring below them.

They are in general of two types—*Gravity* dams or those that depend on their weight to resist sliding and overturning, and *Reinforced concrete* or *steel* dams, that depend on their sterngth to resist stress, and their anchorage for their stability.

The Gravity dam was used at a very remote period in history for the construction of reservoirs. Ancient ruins in India and Ceylon are all that are left of the labors of the prehistoric engineers. They used walls of earth across the valleys to form their reservoirs and do not appear to have had any knowledge of the science connected with the work.

In the sixteenth century masonry dams were first used in Spain, and their great massiveness cannot but excite our admiration, yet they are decidedly faulty in design.

It was not until 1850 that the French engineers first advanced a theory on the design of the masonry dams. This theory has been somewhat modified from time to time, engineers of all nations contributing something toward our present idea of the theory involved.

Besides masonry and earth, there are dams constructed of the following materials:—Concrete, reinforced concrete, rock fill, timber, steel and also a type of movable dam constructed of steel or wood. The dams that are in general use, are those constructed of masonry, concrete and timber. Reinforced concrete is but little used at present but is becoming more popular and will in time be used to a very great extent. Only the theory of the gravity dam will be treated here.

At present, all the laws which the internal stresses in dams follow, are not known, so that assumptions are made that give approximate results. The assumptions are that all the walls of the dam are rigid and that it will resist the thrust of the water by its own weight.

There are four ways in which the dam may fail:

1. By overturning.
2. By crushing.
3. By sliding or shearing.
4. By rupture from tension in the toe or heel.

To insure safety against these, the dam must be designed to comply with the following conditions.

1. The resultant of all forces acting on the dam must lie within the middle third of the base. This precludes any possibility of tension in the base and gives a safety factor of at least two against overturning.

2. The maximum pressures in the material used, or in the foundations must never exceed certain fixed limits. These limits vary, of course, with the material of which the dam is constructed, and are found experimentally.

3. The dam must be sufficiently thick in all parts to resist the shock of the wave action and floating logs, etc.

It is impossible to obtain a formula for the thickness of a dam that will satisfy at once the above four conditions. But by designing a dam to suit the first two, the others will be fulfilled.

Evidently, at the surface of the water, the pressure of the water on the dam will be zero. The pressure "p" of the water at "h" feet below the surface $= 62.5h$ or $(p - 62.5h) = 0$ which is a straight line formula. Therefore if it is assumed that the front face of the wall be vertical, the back wall will be a straight line starting at the face at the top of the dam where the pressure is zero, and gradually diverging from it as "h" increases. The dam would, therefore, have a cross section shaped like a right angled triangle with the vertical face upstream. This form of dam has the minimum area that fulfils the conditions that the resultant of all forces must be within the middle third.

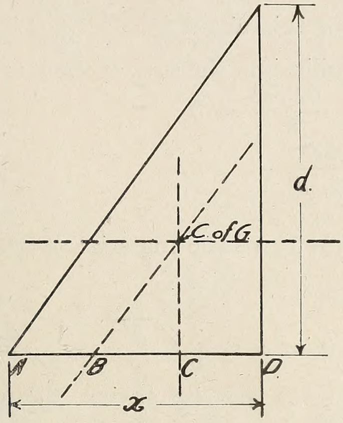

Fig. 1

Consider the ideal section. (See Fig. I.)

Let x = length of base.

d = depth of water.

w = weight of 1 cu. ft. of material of which the dam is constructed.

The maximum and minimum conditions that will occur are when the reservoir above the dam is full and when it is empty.

When it is empty the only stress acting on it is its own weight, which acts at the centre of gravity and tends to crush.

Now the centre of gravity of a triangle is $^1/_3$ of the height from the base or $^1/_3$ of "x" from "d." A dam of triangular cross section will fulfil the conditions when it is empty.

When the reservoir is full, to satisfy the condition that the resultant must be within the middle third it must lie between the points "B" and "C" on the base. Then, to find the value of "x" take moments about the point "B."

The forces acting on the dam are,—The pressure of the water on the upstream face of the dam, tending to overturn it, and its own weight, keeping it in position.

Its weight in a section 1 foot long $= \frac{w\,x\,d}{2}$

The moment of this about $B = \frac{w\,x\,d}{2} \times \frac{x}{3} = \frac{w\,x^2\,d}{6}$

The pressure at the top of the dam due to the water = 0

The pressure at the bottom of the dam due to the water = $62.5d$

The average pressure $= \frac{62.5d}{2}$

Then the total pressure $= \dfrac{62.5d^2}{2}$

The moment of this about $B = \dfrac{-62.5d^2}{2} \times \dfrac{d}{3} = \dfrac{-62.5d^3}{6}$

But for the equilibrium the sum of the moments $= 0$

$$\therefore \frac{w\,x^2\,d}{6} - \frac{62.5d^3}{6} = 0$$

$$\therefore w\,x^2 = 62.5d^2$$

$$\text{or } x = \sqrt{\frac{62.5d^2}{w}}$$

The specific gravity of the material of which the dam is constructed $= \dfrac{w}{62.5} = r$

$$\therefore \text{ by substitution } x = \sqrt{\frac{d^2}{r}} = \frac{d}{\sqrt{r}}$$

In investigating the security against sliding it is assumed that no provision is made to anchor the dam other than the friction between the material of which the dam is constructed and its foundation. In every case where a dam is built in actual practice, it is anchored. The foundation is roughened by putting in a few shots of dynamite or by trenching, so that all danger of sliding is eliminated. But in investigating the case this is not considered.

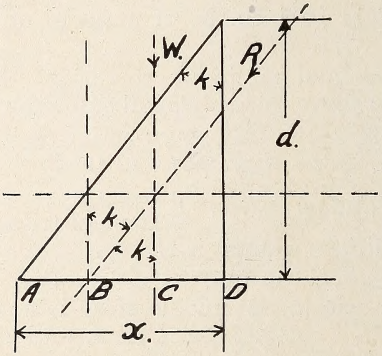

Fig. 2

If moments are taken about the point "B" (See Fig. 2) the resultant will be parallel to the inclined face of the dam.

Now suppose that the wall is cut by a horizontal plane at any point. There are two forces that keep the upper part from sliding on the lower.

1. The cohesion of the masonry.
2. Friction.

Therefore, for equilibrium $P \overset{=}{<} f\,w\,cl.$ where "f" is the coefficient of friction of the material used, on itself.

"c" is the cohesion of the material used. It is considerable for masonry and greater for concrete.

"l" is the length of any joint

Consider cl as the factor for safety.

Then $P = f\,W$

$$f = \frac{P}{W} = \tan \text{“}k\text{”}$$

But $P = \dfrac{62.5d^2}{2}$

and $W = \dfrac{w\,x\,d}{2}$

But $x = \sqrt{\dfrac{d}{r}}$

$\therefore W = 2\sqrt{\dfrac{wd^2}{r}}$

and $f = \dfrac{P}{W} = \dfrac{62.5d^2}{x} \times \dfrac{x\sqrt{r}}{wd^2} = \dfrac{62.5\sqrt{r}}{w}$

but $\dfrac{w}{62.5} = r$ the specific gravity

$\therefore f = \dfrac{\sqrt{r}}{r} = \dfrac{1}{\sqrt{r}}$

Take 2 and 3 as the limiting values of r

Then $f = \dfrac{1}{\sqrt{2}}$ to $\dfrac{1}{\sqrt{3}} = 0.577$ to 0.707.

But experiment proves that the limiting value of f is 0.75.

Therefore, if $x = \dfrac{d}{\sqrt{r}}$ the dam will be secure against sliding.

In investigating the security against crushing, it is assumed that the dam will be designed so that the resultant of all forces will lie within the middle third of the base. Then the conditions of maximum and minimum compressive stresses in the foundation, will be when the reservoir is empty and when it is full. In the one case, the resultant of all forces will be $\frac{1}{3}x$ from the upstream and in the other $\frac{1}{3}x$ from the down stream face. The maximum unit pressures will be at the two faces. In either case the condition may be represented as in Figure 3.

"$A\ D$" is the length of the foundation or joint, and "B" and "C" are points each $\frac{1}{3}x$ from "A" and "D."

"p" is the maximum unit pressure and is at the face. The pressure at the other end of the joint is 0.

Then the forces acting on the base $= W$ or weight of the structure, acting at "B" and the reaction of the foundation $\dfrac{(p + o)}{2}x$.

These counter-balance one another.

Therefore $\frac{(p + o)}{2} x = W$ (weight of the structure)

$$p = \frac{2W}{x}$$

But $W = \frac{dx}{2} x w$

Where w = weight of a unit mass of the material used.

Therefore $p = 2\frac{dxw}{2x} = dw$

or $d = \frac{p}{w}$

This is the limit to the height that the dam may be built. For masonry it may be safely carried to 130 feet and higher, depending on the kind of masonry, and for concrete, to almost any height. Therefore, the design holds good against crushing for ordinary heights.

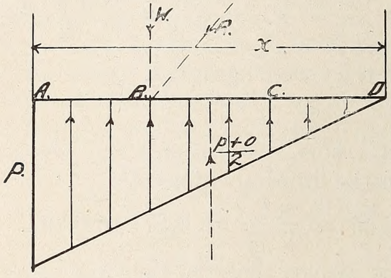

Fig. 3.

However, the design must be modified to satisfy the condition that it be able to withstand the shock due to wave action and floating bodies. This can be done quite easily by giving it sufficient width at the top. If desired, it may be made wide enough at the top to serve as a roadway and should not be narrower than four feet. A cross section of the dam will then be as in Fig. 4.

Here, "y" will be determined by conditions. "z" may be found by considering the top part as a little dam, taking the moments about the point $F = \frac{y}{3}$ from E and putting the sum of the moments $= 0$. This gives an equation in which "z" is the only unknown. Similarly "x" may be found by taking moments about "B" of all the forces acting on the dam. The only difference from the method used in the case of the triangular profile, is that the moments due to the weight of the dam, are found in two parts, the rectangular part with "y" as the top width and "d" as the depth, and the triangular part with $(x\text{-}y)$ as the base and $(d\text{-}z)$ as the height.

The condition that the resultant must lie within the middle third is thus satisfied when the reservoir is full. When it is empty it will be very slightly less than $\frac{x}{3}$ from "D." The tension in the heel thus caused is so slight that it may safely be disregarded.

The water conserved by the dam must be carried to the wheels. There are two general methods in which this can be done.

1. By means of a closed flume or penstock.
2. By means of an open flume.

In the first instance, the end of the flume or penstock must be in the wall constructed like a dam. This is called the forebay wall.

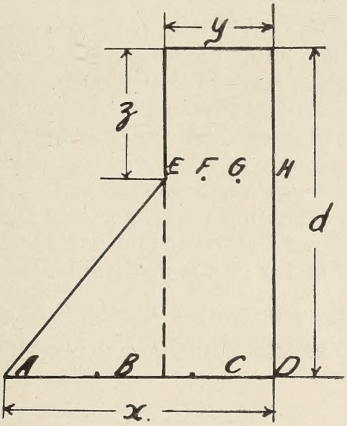

Fig 4.

There may be several forebay walls in some instances, when special protection is required against ice or other debris.

The end of this flume must be protected with racks or screens to take out any floating matter and ice. In designing them and their supporting structure it is advisable to consider them as a dam. So that, if they should ever become totally blocked with debris, they will be able to withstand the total pressure of the water. In practice the following figures are often used.

Fine Racks—Clear space between bars ¾ to 1½ inches, bars of wrought iron or steel ½ to ¾ ins., or even 1 in. thick by 4 to 5 ins. wide.

Coarse Racks—Clear space between bars, 3 ins. bars of wrought iron or steel ½ to ¾ ins. or even 1 in. thick by 4 to 5 ins. wide.

The racks must have a total clear area for the passage of water much in excess of the total area of the penstock inlets to prevent loss of head when the rack is partly clogged. To give a larger passage area and to facilitate cleaning, they are inclined.

They are best made in sections about 3 or 4 feet wide as they are then easily handled. They must be very firmly fastened in place, particularly in cold climates, where the ice freezes to them. Otherwise, any change of water level in the head race would raise them from their bases.

The head gate is provided to shut off the water from the penstock. In the past is was generally made of wood, but modern practice is to construct it of steel plates, especially if it is large. It is better to put a small bypass beside it to equalize the pressure on either side of it before opening it.

The head gate may be operated by means of racks and pinions, of screw spindles, either by hand, mechanical or electrical power or by hydraulic lifts. In cold climates the head gates must be very carefully designed so as to preclude any danger of freezing when open or closed.

Stop logs should be provided in front of them so that the water can be shut off and the gates made accessible for repairs.

After the head gate, comes the penstock. This takes the water from the head works to the turbine. In the case where the wheel is placed in an open flume, there is, of course, no penstock. The penstocks are usually made of steel with countersunk rivets to give a smooth finish. They are also constructed of reinforced concrete and wood stone. In designing them, a safety factor of not less than 4 should be used and for the lower end where the water hammer is the greatest, a safety factor of 6 is preferable.

PENSTOCK AND DRAFT TUBE

In designing the penstock and draft tube the following formula is used.

$$t = \frac{dR}{2S}$$

Where t is the thickness of the shell
R is the unit pressure in pds. per sq. in.
d is the diameter in ins.
s is the permissible stress in the material.

Pipes carrying water for power purposes are subject to great pressure due to the quick closing of the gates by the governors. The moving water acquires a momentum proportional to the product of the weight and velocity. The penstock must be made strong enough to resist this or else some other means must be provided for the escape of the energy of the water. There are two means of providing for it.

1. By means of a surge tank.
2. By means of automatic spring valves.

The surge tank or stand pipe does two things. (1) It acts as a relief valve in case of excess pressures in the penstock. (2) It furnishes a supply of energy to take care of sudden increases of load while the water is accelerating, and dissipates the excess kinetic energy of the moving water column at the time of sudden drop in load.

The least capacity of this tank should be the amount of water the penstock will carry in twice the time it takes the governor to close the turbine gates. It should be placed as close to the turbine as possible and must be protected from freezing. The top of it should be on a level with the surface of high water at the penstock inlet. Large tanks may be constructed of steel, concrete or wood stave.

The safety valves are only used where the head is so great that the pressure on the penstock would be excessive when the surge tank is full. There should be enough of them to discharge, when open, the full flow of the penstock.

The draft tube may properly be called part of the penstock, for by it, the head between the wheel and tail water elevation can be utilized, and thus, the wheel can be placed above tail water elevation. This is possible by the action of suction, pull or draft exerted on the wheel by the water. But the draft tube must be air tight so that a vacuum is created in the tube.

It is so designed that the water, on leaving it has little or no velocity, so that the turbine uses nearly all of the head due to the velocity of the water, as well as the head due to the position above the tail water elevation.

Theoretically a draft tube of as great a length as the suction pipe of a pump, can be used, but practically it should never be longer than 20 to 25 feet and should be made as short as possible. For large turbines particularly, it is almost impossible to maintain a working head with a long draft tube.

The draft tube is made of iron, steel or concrete, and in cases where concrete is used in the construction of the power house, it may be built in with the foundation.

Machinery

The selection of the machinery is a very important part of power development and one that is very hard for an engineer to do satisfactorily. Therefore, it is generally left altogether in the hands of the manufacturers. They are given the size of the unit and the working head and are asked to submit tenders for the supplying of the machinery. This is very unsatisfactory, for it gives the engineer no check on the manufacturers. They are very apt to be much more enthusiastic than they should be over the merits of their machines, and in the competition of tendering, this is only to be expected. Therefore, more data, or rather limits must be supplied to them when calling for tenders.

The following are the various types of water wheels.

1. The Gravity Type. This type includes breast, overshot and undershot wheels. The efficiency of these is often good but the speed and power are low and they are not adapted to present day conditions. Therefore, they will not be considered further.

2. Impulse Wheels. This type includes the Pelton and Girard wheels. They are kinetic energy wheels; that is, the momentum of the mass of water in its impact on the runner buckets, is the main principle used in the transofrmation of energy into power. The impulse wheel is only used for heads of 300 feet and over. With it

there is no draft tube, consequently the head between the wheel and the tail race elevation, is lost. This is the reason the wheel cannot be used for low head developments.

3. Francis Type or Reaction Wheel. This wheel rotates mostly by the pressure of the water and partly by the velocity. It is used for heads up to 300 feet. The wheel is submerged or placed in a closed flume, and the full head is utilized by means of a draft tube. The Smith, American, Holyoke, Jolly, Hercules, McCormack and Victor turbines are well known wheels of this type manufactured in America.

At Holyoke, Mass., the Holyoke Power Co. have a flume in which to test turbines. This has proved invaluable both to the manufacturers and purchasers of wheels. It has brought the American turbine practice up to its present efficiency, and in it have been tested one or more of almost every series of reaction wheels. The results of these tests reduced to unit head and power, form the basis for the selection of the turbine.

The following equations enter into the computation for the selection of the turbine.

$$K_5 = \frac{n^2 P}{\sqrt{h^5}}$$

where K_5 = the specific speed, or the speed at which the runner will operate when delivering unit horse power under unit head.

n = the number of revolutions per minute.

p = the horse power of the turbine at any given head

$$D = \sqrt{\frac{P}{k_2\, h^{\frac{3}{2}}}}$$

Where k_2 = the constant relation of the turbine diameter to to power.

D = diameter of the wheel in inches.

h = the effective head at the wheel.

In the selection of the turbine the engineer is generally limited as to the speed. The generator or machinery may have to run at a certain speed and power, consequently the turbine speed is fixed. Also, it is better to select a wheel that will furnish essentially the amount of power required, as all machinery will work more efficiently at or near full load conditions. If possible, one turbine should be used instead of two or more because of the difficulty of keeping them in alignment.

The first step in the selection of the wheel is to determine the value of K_5 from the preceding equation. Then from the various manufacturers' catalogues select turbines having a similar value of K_5. If the computed value of K_5 greatly exceeds the values found in the catalogues, the power must be divided into two or more units. As K_5 is directly proportional to "P," by dividing K_5 by the number of units to be used, the K_5 of each can be obtained having a similar fractional value of "P" and can be used in the selection of the wheel.

Having determined from the calculated values of K_5 the different makes and types of wheels that may be used, from the catalogue, get the value of K_2 and substitute in the second turbine equation to get D.

Send to the various manufacturers, the data on the development, head, amount of water, size of unit, in fact a general description of the scheme, and invite tenders for the supplying of the wheels. These tenders should be accompanied by a report of a Holyoke test. From these tests, the values of K_2 and K_5 can be checked, also the several prospective wheels can be compared as to their operation at part gate, and the best one chosen. The selection of the generators, exciter unit, and switch board can be safely left with the manufacturers, but they should be accompanied with a written guarantee as to the efficiency. In choosing the governor, the opinion of the turbine manufacturers is of great importance and in many cases, the manufacturer furnishes both turbine and governor.

The design of the power house proper and placing of the machinery in it, will not be gone into here on account of the time required. It is generally of a very simple design, and strength is about the only consideration. In most cases it is a problem in reinforced concrete.

Velocity Considerations

A velocity diagram is of great assistance in designing. Sudden changes of velocity *must* be avoided and by plotting the velocity as a profile, the places where the design must be changed can be seen at a glance.

The velocity of the water in the head race must not be more than 3 or 4 feet per second if it is at all possible. If the speed is greater than this, there is an appreciable drop causing loss of head; also, with greater speed, the ice will not form on the surface, but will be formed as frazil, which, entering the wheel will wear out the vanes in a very short time. In Europe it is the practice to make the velocity of the water in the races not greater than 1.5 feet per sec., but here, on account of the excessive cold, a river running at 4 ft. per sec. will freeze solid.

A question on which there is a very great diversity of practice is the penstock velocity. The entrance from the forebay to the penstock should be conical so as to gradually increase the velocity from that of the head race to that of the penstock. At the lower end of the penstock the velocity should again be gradually increased or decreased so that the water will arrive at the guide buckets with the same speed that it has to enter them. At the entrance to the draft tube it should have a velocity equal to that with which it leaves the runner buckets and the velocity should be gradually decreased to little or nothing at the lower end of the draft tube. The speed of the tail race should be the same as at the outlet of the draft tube.

It is current practice to make the penstock velocity not greater than 4 feet per sec., but there is very little reason for this. In many cases, it is economical to have a much greater velocity, but each particular case must be considered by itself.

Conditions making a low speed advisable are: low head, great length of penstock, many bends in penstock, variable loads on the turbines and the regulation of the speed of the turbine by changing the amount of water used. The penstock is made large enough to give the required low speed.

Conditions making a high speed permissible are: high head, short penstock, few or no bends, constant load on the turbines and regulation of the turbine speed by a bypass.

The following table gives the highest velocity permissible in feet per sec. in penstocks of 1,000 feet or less. This table is from Modern Turbine Practice, by Thurso.

Diameter of Penstock in feet	4	5	6	7	8	9	10	11	12
Speed of water in feet per sec.	12	11.5	11	10.5	10	9.5	9	8.5	8

The losses in head while the water passes through the penstock, wheel and draft tube are as follows:

1. Entrance Loss. This can be kept low by having a taper piece at the entrance so that any change of velocity will be gradual.
2. Frictional Loss. This may be kept low by having a small velocity in the pipe and by having its interior as smooth as possible.
3. Loss due to bends. Therefore make all necessary bends as gradual as possible.
4. Loss caused by changes in the speed of the water. Therefore make any changes necessary as gradual as possible.
5. Loss due to the speed of the water while leaving the lower end of the draft tube. This loss can be kept down by making this speed as low as possible.

In conclusion, it is evident that the development of a water power involves a complete detailed investigation of the entire project and should be built on the most modern knowledge obtainable. To keep abreast of the times, requires a life of study, but the reward of the engineer is well worth the work and time spent.

Note.—In Part I, the statement that "The Hydro Electric Power Commission for Ontario, and the Commission of Conservation for the remainder of Canada, have started to collect data relative to the rainfall, and to meter the rivers, establishing the relation between the precipitation and flow on each watershed, so that, in the future, we will have to do much less estimating" is incomplete and consequently is liable to be misleading. Although the above mentioned Commissions are interested in the work, yet the work of stream measurement in Canada is being carried on by a number of departments of the Dominion Government, the Commission of Conservation probably having the least of any to do with this work.

In many parts of Canada, but chiefly the Eastern section, including Ontario, the work is carried on by the Department of

Railways and Canals, the Department of Public Works and the Department of Naval Service.

In Western Canada the work is being carried on systematically and the results are being published by two branches of the Department of the Interior, viz.: The Water Power Branch, of which Mr. J. B. Challies is superintendent, and the Irrigation Branch, Mr. F. H. Peters being commissioner. In British Columbia an arrangement has been made between the Provincial Government and the Water Power Branch by which the latter carries on the work under the name of the British Columbia Hydrographic Survey, Mr. R. G. Swan being chief engineer. In Alberta and Saskatchewan the work is under the Irrigation Branch, Mr. P. M. Sauder being chief hydrographer, and in Manitoba, the Manitoba Hydrographic Survey, Water Power Branch, is carrying on the work, Mr. M. C. Hendry being chief engineer.

With regard to the collection of data relative to rainfall, this is done almost entirely throughout the Dominion by the Meterorological Service, the head office of which is in Toronto and of which Mr. F. S. Stupart is director. While there are a great many stations established for the collection of this data, it is a well known fact that the relationship between precipitation and run-off is a very complicated one and reliance upon this relationship often leads to very serious error in the making of estimates of discharge.

BROADENING ENGINEERING COURSES

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The Function of Engineering Education

The function of engineering education is to train engineers. It is not to train men to be draughtsmen, instrument men, inspectors or technical clerks, but engineers in all that we wish the name to imply; not engineers of the past, but engineers of the future Admirable though the record of the engineer of the past has been, we must surpass it. The engineer of the future must engage in activities and assume responsibilities unknown to his professional forbears. He must concern himself quite as much with the promotion and definition of projects, and with the securing and maintaining of the support of those who pay for them as with the physical execution of the work. Along with the lawyer, the physician and the clergyman he must become a custodian of the public welfare and at the same time a loyal and active supporter of every movement for the betterment of his own profession. Through superior ability, character, personality and breadth, he must himself be the solution of the much-discussed professional problem. The bringing forth of such a man is only possible through the enlightened, persistent and concerted efforts of the engineering schools. To this work they must bring all the resources at their command.

The Equipment and Training of the Engineer of the Future

The attainment of the status for which engineers strive is only possible to a body of well-equipped, well-trained men. Heretofore, most of our attention has been directed to equipment and very little to training, regardless of the fact that weapons are useless without a knowledge of their effective use and the ability to bring about situations where they may be employed. A mental storehouse crammed with mathematical formulæ is, to an engineer who cannot formulate the problem arising from certain ascertained economic and physical conditions, quite as useless as a magazine rifle to a prehistoric savage. Equally as powerless is the engineer who can solve the scientific problem and yet lacks the art of persuading the financier or the board of works to allow him to attempt it.

In such equipment and training as has been given young engineers in the past there is much to be criticized. We have taught men how to earn a living but not how to live. We have prepared them to effectually cope with certain eventualities arising at rare intervals in the experience of most men, while we have left them unable to meet the persistent demands of everyday situations. For example, effective expression in written or spoken word, upon which the fortunes of every engineer largely depend, has gone all but unheeded. We have based the equipment and training of three upon some of the needs of one. It would be wiser to reverse the practice.

Whether he develops them through the aid of the educator or by his own efforts, the successful engineer must possess certain personal assets. These may be briefly stated as:

(1) *Technical Efficiency*;
(2) *Personal Fitness.*

(1) *Technical Efficiency.* The scientific and executive duties devolving upon the engineer can be effectively performed only by one who possesses a well-ordered knowledge of his special field, accuracy and speed. These constitute the mechanism, as it were, with which he attacks the problem. While their full development is dependent upon character and capacity, it sometimes happens that in positions of limited range a man of small capacity and weak personality may exhibit in his response something akin to mechanical perfection. No man, however, can successfully discharge a great variety of duties and adapt himself to changing conditions and positions on the basis of technical efficiency alone.

(2) *Personal Fitness.* Personal fitness in the young engineer may be said to depend upon:

(a) Character;
(b) Intellectual Capacity;
(c) Breadth;
(d) Address.

(a) Of the engineer who would succeed, the world demands unswerving integrity, a willingness to accept reponsibility for the failures of others and a rare degree of self control. No single possession contributes more to ultimate success than the power of self-detachment, or the ability to bar out anxious thought at will. There is valuable content in the remark of Cobden, made towards the close of a life of stupendous activity: "If I had not had the faculty of sleeping like a dead fish, in five minutes after the most exciting mental effort, and with the certainty of having oblivion for six consecutive hours, I should not have been alive now."

(b) The value of intellectual capacity to an engineer arises as much from alertness as from reasoning power. Much of Sir John Fowler's success was due to his ability to comprehend a situation almost instantly. Indeed, he said, somewhat facetiously, that if he did not see through a problem at once he never saw through it. In engineering, resourcefulness and originality are of much greater moment than the ability to marshal and retain a vast assemblage of facts on a given subject. The creating, rather than the absorbing, intellect is needed.

(c) To maintain pleasant relations with well-educated, vital people about him and to lay the foundations of professional eminence, the engineer must possess breadth. It is a viséed passport to the circles in which he should move. It endows his social and business life with resources and adaptability analogous to that already found indispensable in his special scientific pursuits. We must frankly admit that engineers in the past have often lacked the breadth that should characterize professional men. Says Mr. Frederick Lynch: "We turn out good engineers, but one of them—quite eminent, too—from one of our great universities asked me, myself, once, 'Who was Shelley?'" It should never be necessary for an engineer to apologize for lack of familiarity with the interests and undertakings of the general public on the ground that he is an engineer. Furthermore, such acquaintance cannot be wholly intellectual and be productive of true breadth. The engineer must feel towards the various human activities about him an enthusiasm that compels some measure of participation. He must possess breadth of sympathies as well as breadth of intellectual tastes.

(d) Since the only offering of the engineer to the world is his personal services, he must be his own ambassador. Those who entrust life and property to him must be satisfied that he personally possesses both character and ability, and on personal address their estimate will be largely formed. In commerce, an illiterate, uncouth man possessing material assets and shrewd enough to select educated, polished representatives may achieve success. In professional life such is impossible. Most engineering engagements worth while are secured through acquaintanceship, but such can be advantageous only to the one who can meet prospective clients or their relatives or friends on their own ground and maintain mutually pleasant relations easily and naturally. The young engineer must speak readily and correctly, possess pleasant manners, be neat and careful in his personl habits, enthusiastic, optimistic and physically vigorous. Sir Harry Johnston states that young men entering the British diplomatic service should be physically commanding in order to impress foreign nations with the stamina of the people whom he represents. That the value of this is by no means limited to the sphere of foreign service is indicated by a typical letter from an employer to the writer respecting applicants for the position of engineering salesman. He wrote: "What I have in mind is a good-sized fellow physically, of good family (which naturally will entail connections), and one who has the nucleus of tact, poise and shrewdness in reading men . . . . . . It is more necessary for a young man to handle himself than to attempt to handle a man on whom he is calling. He should be able to readily adapt himself to the mood in which he finds the man on whom he calls." Frequent expressions of opinion on this matter from men well qualified to judge indicate that too much importance cannot be attached to personal address.

Curricula of the Future

Having gained a clear conception of the kind of equipment and training required of an engineer, the educator must deliberately set about to devise the most effective curriculum for imparting it. In the past much damage has resulted from the effort to fully comprehend in engineering courses all the varying conditions and multiplying fields of practice. The shortening of time spent on fundamentals, the heightening of detail and the pointing out of ever-increasing applications of known principles to new problems, not only involves overloading, but connotes the development of men for immediately-remunerative, subordinate positions rather than for those of a responsible, creative, directive character. A subject, or phase of a subject, should never be featured because it may be useful to young engineers, but only because it promises to be useful to a larger number of engineers than some rival subject.

An effort is being made in many institutions to broaden and deepen engineering education by the introduction of five-or six-year courses. In some cases the plan of requiring a complete separation of professional training from general educational training as in schools of medicine, law and theology, is followed. It is believed, however, that a much better plan is to correlate the two. The first four years might, in themselves, be made to constitute a definite, limited course in fundamentals with an introduction to engineering subjects. Upon their completion the student would be allowed, if he so desired, to go out into the world and fill junior engineering positions or to proceed with another year of specialized professional study. This is the Johns Hopkins plan. Whatever the merits of five-or six-year courses may be, it is obvious that in new countries like Canada the four-year course will, for years to come, be pursued by the great majority of young men entering engineering. Our efforts must, therefore, be largely directed to the development of the best possible course covering four academic years. For this reason, such references as are made to the curricula of other institutions in what follows are limited, unless otherwise indicated, to four year courses.

The selection of subjects best calculated to impart technical efficiency and personal fitness is by no means an easy task. There is a feeling in some quarters that for the promotion of technical efficiency, subjects of an exclusively technical character, bearing as intimate a relation as possible to the student's chosen specialty, should be selected. The writer does not share this feeling. Certain non-technical, general studies can contribute valuable aid to the mastery of a technical field. "Nothing can be truly cultural which is not useful," said President-Emeritus Charles W. Eliot to a Toronto audience a few years ago. If this is true, a judicious selection of cultural subjects should promote technical attainments. For the development of professional technique, the chief reliance must, of course, be placed on technical subjects. The determination of the particular ones best calculated to serve our purposes forms no part of the present discussion.

Although technical studies have value in the attainment of personal fitness, cultural or non-technical subjects must play a more important role. It is believed that those best suited to this purpose are:

(1) *Language and Literature*;
(2) *History*;
(3) *Biography*;
(4) *Philosophy*;
(5) *Political Science and Sociology*;
(6) *Physical and Military Training*.

It may be urged that since certain of these have an important place in the curricula of preparatory schools, they might give place to an equivalent amount of technical work in engineering schools. To this, two objections arise. First, the student generally has an acquaintance with these fields gathered in immaturity and incompatible with the standard of culture demanded of a well educated professional man. Secondly, the dropping of specific instruction in them upon entering college, often means the cessation of the student's interest in these subjects. Four years of concentration upon technical studies at a time when vital changes are taking place in the student himself generally means that tastes are re-formed, or perhaps all but obliterated, and that he never fully regains his interest in literary or historical studies.

(1) *Language and Literature.* Of all the weapons placed in the hands of the engineering graduate, a vital acquaintance with language and literature most nearly approaches universal utility. Through it we gain access to all that is helpful and inspiring in the records and visionings of our own people and of those who speak alien tongues. Through it we impart such help and inspiration as we are able to give. As a means of developing in the engineer those qualities for which the company of men is most eagerly sought—lofty ambitions, refined tastes and ardent enthusiasm—language and literature are of the utmost value.

The need for special instruction of engineering students in English need not here be shown. The inability of the average engineering graduate to express himself clearly and accurately in either speech or writing has been repeatedly pointed out. It has been said that in this age the man of science appears to be the only one who has anything to say, and that he is the one that least knows how to say it. This is unfortunate, for no single circumstance predisposes an employer so much towards an applicant as the clearness and precision with which the stranger states his case. Indeed, what assurance has the prospective client that carelessness, inaccuracy and incoherence in expression will not extend to professional work? There is, too, as Professor Haultain has pointed out, the necessity of the engineer becoming, like the geologist, an effective story-teller.

English, as taught in engineering schools should not be confined to effective self-expression in speech and writing, but should increase the student's interest in reading and in some measure develop in him a standard of critical judgment. The development of appreciation and the formation of discriminating taste is entirely compatible with the perfection of an instrument for transmitting ideas with clearness, precision and brevity. It is thus desirable that any course in English should include not only composition and public speaking, but English literature as well.

English composition is now taught in very many engineering colleges. In most of them it covers not only general composition, but the specialized professional writing of the engineer. The University of Michigan offers elective courses in the Preparation and Presentation of Technical and Scientific Papers, Commercial Correspondence, Engineering Reports and Technical Journalism. Third and fourth year students in the University of Wisconsin may select as one of their subjects a course in Advanced Technical Writing with the study of scientific and technical models. An elective course in technical writing is about to be offered at the University of Minnesota. At the Massachusetts Institute of Technology a feature of the instruction in English is the training of students in the taking of lecture notes. Exercises of great value, closely paralleling much work to be subsequently encountered by the engineer, might be given in the abridgment and presentation in condensed, or perhaps semi-popular, form of professional reports and papers.

No one who aspires to professional status should pass four years of the most impressionable period of his life without enlarging his acquaintance with the best literature. As a source of enrichment of his mental and spiritual life he should develop or preserve an appreciation of the literary treasures of his language. The hazard of atrophied taste should not be invited. The professional school must keep open all avenues to the understanding of life.

Already instruction in literature is given in a number of engineering schools. At the Massachusetts Institute of Technology, elective work is offered in Eighteenth and Nineteenth Century English Literature and the English Bible. The University of Michigan gives a place to studies in Criticism of Prose Fiction and in Criticism of the Drama. The University of Pennsylvania provides courses in the History of English Literature and Language, Nineteenth Century Novelists, English Essayists, Elizabethan and Seventeenth Century Dramatists and the English Bible.

Concurrent with, or subsequent to, the formal course in English literature, a certain amount of supplementary reading should be required. No technical course purporting to train professional men should be allowed to wholly displace the habit of general reading. In order to avoid haste and congestion during the session, and to take advantage of those conditions most favorable to the growth of appreciation, several institutions have adopted the plan of prescribing summer reading. At the Massachusetts Institute of Technology and at the University of Illinois courses of summer reading of a literary, historical and general scientific character are required between the first and second and second and third years. The purposes of these courses are "to increase the acquaintance of the student with literature, history and general science, to develop in him a taste for such reading, and to impress him with the importance of general culture, not only as a source of individual enjoyment, but as a practical aid to professional men in their social and business relations." McGill University requires all students entering the second year, except those in architecture, to have read five specified books and to pass an examination based upon such reading at the beginning of the session. Students entering the third year, except those in architecture, must either have followed a course of summer reading or have prepared a 2,000-word essay. If the former has been selected, an examination must be passed before proceeding with the year. Special assignments involving less reading are made to architectural students.

In addition to providing instruction in the writing of English, several engineering schools give attention to the speaking of it. Certainly nothing is more important to the engineer than the ability to present a case clearly and concisely in the committee room, on the platform, or in the witness box. Nothing so much predisposes a client to give an engineer a chance to appear in these places as the possession of ready, expressive, restrained conversational powers. Courses in public speaking, either obligatory or optional, are provided in Cornell University, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Michigan and Union College. These generally include extemporaneous speaking from outlines and the preparation and delivery of at least one original address. At Union College, public speaking is obligatory for all second and third year students.

A valuable aid in the preparation and presentation of cases is offered in properly-directed engineering society meetings. On a purely voluntary basis, the benefits derived are limited to the comparatively few who prepare papers and take part in the discussions. If participation in the activities of the society were required by the curriculum and credit were given for it, the society might become a valued adjunct to the teaching force. An effort to realize the advantages of the engineering society more fully than is possible under a voluntary system has been made at West Virginia University. At that institution engineering society work is required of all students in the third and fourth years. Each student prepares four papers, two of which he reads and sustains and two of which he holds in readiness for presentation, should the occasion arise. Credit is given both for the papers themselves and for attendance at the society meetings.

Foreign languages are studied in most engineering schools as a means of acquiring technical information not available in English. Usually French or German is required, but Spanish is allowed in certain colleges where special attention is paid to mining and metallurgy. Courses usually cover one or two years. French is generally obligatory for students in architecture and German for those in chemistry. At the Massachusetts Institute of Technology the study of foreign languages has two objects: "that of enabling the student to make use of the languages as instruments in scientific research, and that of giving him general training and culture."

(2) *History.* One of the most potent influences for widening the horizon of the young engineer and extending his interests is the study of history. Current history is especially effective as a stimulus to participation in the activities and thought of his time and in the development of good citizenship. Recognition of the value of historical study has been accorded in a number of institutions. It is commonly given a place in combined five-and six-year courses and in the following cases, among others, has been incorporated in four-year courses. At the Massachusetts Institute of Technology, Modern History is required of all students in the first and second years. A special course in the History of European Civilization and Art is given to architectural students in the third and fourth years. Elective historical courses are provided for all departments in the third year in Colonial Systems and Current Public Problems. At Union College, American History is required of all students in the third year. For the Engineering Administration option, Medieval and Modern History are also required. In the first year at the University of Washington, United States History forms one of the cultural electives and a historical course is also permitted as a fourth year elective.

A phase of historical study that would not only be of commanding interest but, at the same time, of practical value to the young engineer is the history of engineering. An undoubted source of inspiration to those just entering upon the study of engineering, and an incentive to historical reading in this field might be afforded by a few graphic lectures outlining the beginnings of, and the notable achievements in, engineering. Isolated lectures of this kind have been given in the University of Toronto. At Cornell University, the University of Illinois and the University of Minnesota they form a regular feature of the sessional activity. A little more work of this kind would greatly heighten the enthusiasm of the student for his profession.

(3) *Biography.* As a directive influence in character-building,

no field of general reading offers more than biography. From it the student is able to supplement his own meagre experience with that of the great men of all time and to live over again with heroic souls the supreme moments that made them immortal. Beyond one or two interest-stimulating lectures each year on the lives of celebrated engineers, formal instruction is not required. It would be desirable in any course of summer reading for engineers to prescribe one or two biographies of engineers. Smiles' Lives of the Engineers, Goddard's Eminent Engineers, and Mackay's Life of Sir John Fowler, are worthy of the close study of every engineer-to-be.

(4) *Philosophy.* Apart from the personal satisfaction and self-improvement to be derived from philosophic studies, the engineering student acquires from them knowledge of immediate guiding value in professional pursuits. Logic, ethics, and psychology have a content for the engineer quite as much as for any other professional man. From logic he should derive a clearness of analysis and presentation not possible with the wholly indirect instruction afforded in technical courses. Ethical principles must form the basis of professional conduct. Psychology, through its correlation of motives and their manifestations would obviate much blind groping and friction in dealings with men. The value of these studies has already been recognized in engineering schools. At the Johns Hopkins University an obligatory course in philosophy is prescribed for all students in the fourth year, and at the University of Pennsylvania for certain departments of the fourth year. The University of Washington offers courses in philosophy as cultural electives in the first and third years. In recognition of the importance of sound professional ethics, Union College provides a course of lectures on topics pertaining to the training and qualifications of an engineer and to the engineering profession in general.

(5) *Political Science and Sociology.* A course in elementary political science and sociology should do much to promote a desire for effective citizenship among engineering students. Lively interest in public problems would arise with a careful examination of the relation of fundamental economic principles to present-day industrial and social conditions. Economic studies, of course, have a direct technical value to engineers, especially to those who are to occupy administrative positions or to undertake work involving both commercial and scientific activities.

Much attention is given by engineering colleges to instruction in this field. In addition to elective courses offered in a number of institutions, regular courses in elementary economics are provided in Cornell University, the University of Illinois, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Minnesota, Union College, the University of Toronto and the University of Washington. McGill University provides a course in engineering economics especially adapted to the needs of the engineer. The third year electives in the curriculum of the Massachusetts Institute of Technology include Economic History, Railroad Economics, Labor Problems, Municipal Government, and International Law.

The University of Minnesota provides courses in Railway Economics and American Government including, a study of the organization and present workings of the national, state and local governments. At Union College fourth year students selecting the Engineering Administration option receive instruction in Comparative Politics and International Law. In many of these institutions courses are given in Banking and Finance, Commercial Law, Accounting, Contracts and Specifications and Cost-keeping. These, however, are technical economic subjects, and as such do not enter into present consideration.

(6) *Physical and Military Training.* Nothing stands out more clearly in the careers of great engineers than the stupendous part that physical endurance has played in the winning of success. It is unkind to allow a young man who contemplates a life work demanding exceptional physical energy to neglect physical training for perhaps the four most critical years of his life. Many engineering colleges appreciate this and require physical training in at least one year of the course, generally the first year. The habit of attending to the physical well-being thus formed will probably be continued by most men. Physical training is obligatory in Cornell University, the University of Illinois, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Michigan, the University of Pennsylvania, Queen's University and Union College. At the University of Pennsylvania it is required for the entire four years. In addition, lectures on personal hygiene are given at many institutions, among others, McGill University, the University of Minnesota, the University of Pennsylvania, the Massachusetts Institute of Technology, and the University of Toronto. A useful aid to social service is contained in the lectures at the University of Pennsylvania, which include instruction on gymnastic systems for school, playground and college, and the application of exercise to the improvement of defectives.

While the desirability of placing military training on an obligatory basis is debatable, there can be no question as to the value of such training in setting up the student and promoting his quickness of response. The sense of citizenship established in enrolling one's self for national defence is especially compelling in those, like the student, who take the step early in life. In a number of engineering colleges of the United States military training is obligatory, as at Cornell University, the University of Illinois, the Massachusetts Institute of Technology, and the Universities of Minnesota, Washington, and Wisconsin. It is optional in McGill University and the University of Manitoba.

Experience has shown that undoubted advantages to the student attend the introduction of voluntary military training. The present war will probably bring about its establishment in many engineering schools.

Making Room for Non-Technical Subjects

Less difficulty is experienced in selecting a list of subjects of general educational value to the engineering student than in agreeing upon the subjects that they shall displace. Each member of the teaching staff is persuaded that it is not his own special work that should be reduced but that of someone else. Under these circumstances, the only possible basis of settlement is compromise. But on what basis shall it be made? It is believed that if certain broad principles were kept firmly in mind the difficulties incident to the undertaking would be considerably lessened. Some lines of policy that would probably meet with general support among engineering educators of to-day are:

(1) Curricula should be based upon the requirements of the majority of the students, not of the minority;

(2) Reading courses, that is courses requiring no elucidation by the teacher, should be reduced to a minimum;

(3) Technical detail and descriptions of the methods of practice should be limited to the minimum necessary for clear illustration of the general principles;

(4) Cultural subjects of universal utility should be obligatory and those of lesser utility, optional.

SUGGESTIONS FOR CHEMICAL ENGINEERING STUDENTS

By J. A. DeCew, B.A.Sc., '96

One of the newest branches of engineering science is that of the chemical engineer. This profession, which has evolved and established itself, is a distinct branch of engineering because of the wide field for work and the necessity for specially trained men to carry it out.

In many respects the chemical engineer may be said to be a development from the industrial chemist, as it has been found possible for the industrial chemist to so increase his experience along engineering lines that he is able to undertake and carry out such engineering work as is built up around a certain group of chemical problems. It has been more difficult for the engineer without special chemical training to carry out chemical engineering work, than for the chemist. The latter is bound to acquire certain skill and experience in manipulating apparatus and when this apparatus becomes a commercial unit, it has reached the sphere of engineering practice. At the present day, however, it is possible for men to get an excellent training in chemical engineering which includes special instruction and experience, not found in the training of either the chemist or the engineer.

Quite a little has already been written regarding the education of the chemical engineer and his function in the industrial field, and the profession is by no means as unknown or unappreciated as it was a few years ago. The suggestions I would make to students who are interested in or contemplate chemical engineering work, are not related to the courses of training which may be established in different institutions but rather to the industrial opportunities which lie open to the man who has trained his mind in the solution of chemical problems on an engineering scale. Although the field is wide from a purely professional point of view, to the man who combines this general training with a concentration upon a special series of problems of commercial importance, there is, in the opinion of the writer, a special advantage in this class of education which is now available, for general commercial work. In practically every industry there are chemical problems which must be dealt with by every executive. Where a man is engaged in a manufacturing industry or is employed as manager or superintendent for others, he must face the ever present problems which have both an engineering and chemical character. A chemical knowledge of the different materials that are being used in every walk of life has become essential to their proper manipulation and exploitation. If a man should go in for railway engineering or management, he might be called upon to deal with problems in which the chemical properties of materials such as iron, steel, wood, cement, rock, etc., would have an important bearing upon the problems. Efficient maintenance of railway lines depends upon the chemical as well as the physical properties of the materials in use. In the manufacture of many of the staple products used, such as paper, leather, rubber, soap, sugar, starch, the chemical processes involved are of basic importance and on these lie the chief responsibility for the quality of products.

When it becomes fully appreciated in trades that the engineer is better equipped to deal with problems of general management than the man with only an office training, it would also be recognized that the chemical engineer is specially qualified for the control of industrial problems of a chemical nature. From his training the chemical engineer is one who is constructive and creative rather than analytical and his knowledge is intimately related to the problems on which the conversion of materials depends. It is obvious that the better a man is trained for the kind of work he is about to follow, the easier it will be for him to advance rapidly in that work. The student who has in mind executive work in connection with manufacturing processes will appreciate that the chemical engineering course offers the best average training for many manufacturing industries in which he may find his life's work.

H. N. Macpherson, B.A.Sc., '14, is inspector for the Board of Highway Commissioners of Saskatchewan. He has been inspecting on provincial bridge work during the summer.

W. D. Walcott, B.A.Sc.,'14, is with the Public Works Department of the Jamaica Government, as surveyor on road location and other work.

C. E. Richardson, '10, is division engineer with the British Columbia Hydrographic Survey, at Nelson, B.C.

J. A. Elliott, B.A.Sc., '14, is assistant engineer with the British Columbia Hydrographic Survey, at Nelson, B.C.

N. C. Stewart, B.A.Sc., '09, is engaged on D.L.S. work near Golden, B.C.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE
AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

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Per year, in advance	$2.00
Single copies	.20

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EDITORIAL

DR. ELLIS IS ACTING DEAN

Dr. Ellis has been appointed Acting Dean to assume the duties from which death called away our late Dean Galbraith. In 1878, upon the organization of the School of Practical Science, Dr. Ellis became assistant to the Professor of Chemistry, Dr. H. H. Croft, and since that time has been one of the associates of the late dean in the work connected with the upbuilding of the "School." The graduates and undergraduates therefore look to him with confidence to uphold the traditions of Dr. Galbraith, whose colleague he has been for so many years.

Dr. Ellis has a host of friends among the graduates of the various years since the founding of the "School," who cherish a very high respect for him and who are glad to know that he is still able to take up the reins so long controlled by his intimate personal friend.

Thompson-Atkinson

On Tuesday, September 15th, Mr. J. M. Thompson, B.A.Sc., '13, of the staff of the Hamilton Bridge Works, Hamilton, Ont., was united in marriage to Miss Cora Blanche Atkinson, daughter of Mr. and Mrs. Robert Atkinson, Caledonia, Ont.

Huether-Wilkins

On Wednesday, September 23rd, Mr. D. J. Huether, B.A.Sc., '08, was united in marriage to Miss Etta Alderson Wilkins, daughter of Mr. and Mrs. M. Wilkins, Mount Forest, Ont.

Redfern-Kinghorn

On Wednesday, September 9th, Mr. C. R. Redfern, B.A.Sc., '09, engineer for P. Lyall & Sons Construction Co., Toronto, was united in marriage to Miss Bessie Inglis Kinghorn, daughter of the late D. W. Kinghorn and Mrs. Kinghorn, Toronto, at the home of the bride's mother on Geoffrey Street. Mr. and Mrs. Redfern will reside in the Georgian Apartments, St. George St.

The following "School" men have gone with the first Overseas Expeditionary Force from Canada to England, in addition to those mentioned in last months' issue:—P. J. McQuaig, '04; — Bevan, '05; A. J. Code, B.A.,Sc., '10; I. M. R. Sinclair, '17; E. P. Muntz. B.A.Sc., '14; J. J. Hanna, B.A.Sc., '14.

F. S. Falconer, B.A.Sc., '09, is engaged on Topographical Survey work near Revelstoke, B.C.

C. G. Hoshal, B.A.Sc., '09, and G. G. MacLennan, B.A.Sc., '10, are with the Ontario Hydro Electric Power Commission, at Eugenia, Ont., on construction work in connection with the development of electric energy at that point.

Edwin E. H. Hugli, B.A.Sc., '14, is with C. E. Deakin, Ltd., of Montreal, on the erection of the new concrete plant of the Canadian Kodak Co. at Mount Dennis, near Toronto.

S. G. Bennett, B.A.Sc., '14, has left to take a post graduate curse in Physics at Oxford University.

F. T. McPherson, '15, is in the office of the city engineer, Saskatoon, Sask.

A. C. Goodwin, '02, is in charge of testing and inspection of materials for the Ontario Hydro Electric Power Commission, Toronto.

J. N. Goodall, '04, is superintendent of the High Tension Construction department with the Ontario Hydro Electric Power Commission, Toronto, Ont.

Pick, B. W., '11, is with Smith & Phillips, engineers, at Regina.

Pickering, A. E., '04, is manager of the Tagona Light & Power Co., Sault Ste. Marie, Ont.

Piggott, R. B., '09, has as his address 157 Wentworth St. S., Hamilton, Ont.

Pinhey, C. H., '87, has a land surveying practice at Ottawa, Ont.

Pinkney, D. H., '03, is mechanical engineer and chief draftsman in the pipe mill department of the Lorain Works of the National Tube Co., at Lorain, Ohio, U.S.A. His address is 142 Princeton Ave., Elyria, Ohio, U.S.A.

Pivnick, M., '08, has a practice as dental surgeon. We do not know his address.

Playfair, N. L., '92. We understand that he is at Midland, Ont.

Plunkett, T. H., '03, is a Dominion and Ontario land surveyor at Meaford, Ont.

Ponton, G. M., '09, is consulting engineer at Calgary, Alta. His office is at 513-516 Beveridge Building, Calgary.

Pope, A. S. H., '99. When last heard from he was a member of the firm Pope & Wilcox, electrical and mechanical engineers, Portland, Oregon.

Porte, E. H., '11. Address not known.

Porte, W. B., '06, has Brown's Corners, Ont., as his home address.

Porter, C. J., '09, is with the Texas Power & Light Co., Dallas, Texas.

Potter, R. B., '07, is assistant engineer in the roadways department at the City Hall, Toronto. His address is 235 Garden Ave., Toronto.

Powell, G. G., '02, of 129 Springhurst Ave., is assistant city engineer for Toronto.

Power, G. H., '01, is consulting engineer with Chipman & Power at 47 Canada Life Building, Winnipeg, Man.

Prentice, J. M., '92 (deceased).

Price, H. W., '01, is associate professor of electrical engineering at the University of Toronto.

Pratt, F. M., '11. His address is 343 Nepean St., Ottawa, Ont. He is resident engineer in the construction department of the E. B. Eddy Co. at Hull, P.Q.

Porchnow, F. E., '07, of 506 Ellicott Square, Buffalo, N.Y., is with Wilhelm, Parker & Ward, patent attorneys, of that city.

Proctor, A. I., '09, lives on King St. E., Hamilton, Ont. We do not know his occupation.

Proctor, E. M., '08, is designing engineer in the department of railways and bridges at the City Hall, Toronto.

Procunier, J. F., '07. His home address is Bayham, Ont.

Proudfoot, H. W., '97 (deceased).

Publow, C. F., '08, is on the staff of the Toronto Hydro Electric System, Toronto, Ont.

Pullan, H., '11, is in business with his father at 490 Adelaide St. W., Toronto.

Pullan, E. F., '05, manager of the Alexo Mine, Iroquois Falls, Ont.

Purser, R. C., '06. His address is 32 Glengarry Ave., Windsor, Ont. He has been engaged on D.L.S. work in the West during the last three years.

Pye, D. E., '10. His address is Cranbrook, B.C.

Q

Quail, J., '09, is with the Manitoba Bridge and Iron Works.

Quail, H. C., '13, is in the high tension construction department, with the Ontario Hydro Electric Commission, Toronto, Ont.

Quance, G. E., '07, is secretary-treasurer of the Delhi Light & Power Co., Limited, Delhi, Ont.

Quinlan, L. J., '11, is in the topographical surveys branch of the Department of Interior at Ottawa, Can.

R

Railton, L. W., '11, is with the P. G. E. Railway, Cheakamus, B.C.

Raine, H., '07. His address is 197 Fulton Ave., Toronto, Ont. He is structural engineer with Prack & Perrine, architects and engineers, Toronto.

Ramsay, W. S., '10. Address not known.

Ramsay, G. L., '05, has an Ontario land surveying practice at Sault Ste. Marie, Ont.

Ramsperger, A. F., '09, of 22 Callender St., Toronto, is with the Dominion Bridge Company on the designing staff.

Rannie, J. L., '07, is with the Geodetic Survey branch at the Dominion Observatory, Ottawa, Ont.

Ranson, J. T., '08, of 128 Grenadier Rd., Toronto, has a practice as land-surveyor with offices at 2 Temperance St. He is also demonstrator in surveying at the University of Toronto.

Ratz., E. G., '13, was with the Canadian Westinghouse Co. at Hamilton, Ont., when last heard from.

Ratz., J. E., '11, is with the Geodetic Survey branch of the Department of Interior at the Dominion Observatory, Ottawa.

Ratz., W. F., '02. Deceased.

Raymer, A. R., '84, is assistant chief engineer, P. &. L. E. Ry., Pittsburg, Pa.

Rayner, G. W., '05, is with the Ontario Rock Co., Lumsden Building, Toronto.

Raymond. D.L.C., '04, is with the Bishop Construction Co., 614 Traders Bank Building, Toronto.

Read, F. N., '11, is with the Department of Public Works, Regina, Sask.

Redfern, B. J., '10. Deceased.

Redfern, W. B., '08, is town engineer at Steelton, Ont.

Redfern, C. R., '09, is engineer for P. Lyall & Sons Construction Co.

Reid, E. V., '11, is with Ross & Macdonald, architects, 1 Belmont St., Montreal, and Traders Bank Bldg., Toronto.

Reid, F. B., '04. Address not known.

Revell, G. E., '99, is engineer with Green Bros. & Burden, at Nelson, B.C.

Richardson, C. E., '10, is Division Engineer with the B.C. Hydrographic Survey, at Nelson, B.C.

Richards, E., '99, is Dominion appraiser, in the customs department at Ottawa.

Richardson, F. L., '08, is construction superintendent for Miller, Cumming & Robertson, contractors, 50 Front St. E., Toronto.

Richardson, G. H., '88, is managing director of the Yellowhead Pass Coal & Coke Co. His business address is 24 Credit Foncier Building, Edmonton. Alta.

Richardson, C. W. B., '07, was with the Dominion Bridge Co. at Ottawa, when last heard from.

Richardson, W. A., '11, is with Bates & Roger Construction Co., of Chicago, and Spokane, U.S.A. During the summer he has been engineer for that firm on the erection of a half-mile bridge across the Fraser River at Fort George, B.C.

Richardson, W. L., '05. His address is 2303 Mercil St., Fresno, Cal.

Ricker, H. A., '08, is with the Canadian Westinghouse Co. at Hamilton. His address is 93 Sanford Ave., Hamilton, Ont.

Riddell, J. M., '13, is at present at St. Obert, Que., where he is engaged on work for the Topographical Surveys branch, Department of Interior, Ottawa.

Riddell, M. R., '04. His address is 86 Spadina Rd., Toronto.

Ridler, A. A., '07, is superintendent of the Constructing & Paving Company Limited, Toronto.

Rigsby, J. P., '01, is with the Turnbull Elevator Works, Toronto.

Ritchie, H. C., '10, was with the Department of Public Works at Calgary, Alta., when last heard from.

Ritchie, J. E., '13, is secretary of the University of Toronto Engineering Society.

Roaf, J. R., '00, is with the Yellowhead Pass Coal & Coke Co., at Bickerdike, Alta.

Robertson, A. R., '08, is sales engineer with McGregor & McIntyre, Toronto.

Robertson, C. S., '13, is with the Provincial Board of Health of Ontario, at their experimental plant, Clifford St., Toronto.

Robertson, F. A., '08, of Meldrum Apts., Toronto, is in the publicity and sales engineering department of the Toronto office of the Canada Cement Co., Limited.

Robertson, H. D., '02, is associated with Miller, Cumming & Robertson, engineers and contractors, 50 Front St. E., Toronto.

Robertson, J., '84, of 531 Palmerston Boulevard, Toronto, is commissioner of The Canada Co.

Robertson, J. M., '93, has a practice as consulting engineer at 14 Board of Trade Building, Montreal, P.Q.

Robertson, N. R., '06. His address is 415 Winch Building, Vancouver, B.C.

Robertson, D. F., '03. Address not known.

Robinson, J., '91. Deceased.

Robinson, F. J., '95, is deputy minister of public works at Regina, Sask. His address is 2839 Angus St., Regina.

Robinson, A. H. A., '97. His last address on our records is 497 Gilmour St., Peterboro, Ont.